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ACUTE RESPIRATORY DISEASES AMONG TROOPS WITH ESPECIAL REFERENCE TO EMPYEMA

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This study of acute respiratory diseases among troops details the incidence of various respiratory conditions, measles and rubella in their relation to each other and to the more serious conditions, pneumonia and empyema. Out of a total of 9,691 admissions to a base hospital, 4,443 were cases of acute respiratory infections and are the ones included in this analysis. Table 1 and Chart 1 show how these infections appeared in waves, sudden both as to number and severity. During a period of about three months (from Sept. 25 to Dec. 16, 1917) there were 333 cases of measles (including rubella) only three cases having complications—otitis media in each instance, one case requiring a mastoid operation. This period was relatively free from respiratory infections, but when in January the infections of the respiratory tract were very prevalent and severe, not only did there occur many cases of pneumonia and empyema but the cases of measles developed respiratory infections of a severe type, usually of streptococcus origin (See Table 1). The number of cases of measles and rubella did not increase materially but the complications, often serious or fatal, increased greatly, there being 14 cases of empyema, with 9 deaths, and 4 cases of pneumonia. Of a total of 58 consecutive cases of measles about this time the complications were as follows: empyema, 5; pneumonia, 2; tonsillitis, 3; otitis media, 10; and severe bronchitis, 2.

In cases of measles developing empyema it has been definitely and repeatedly observed that the lungs did not at any time become free from râles and that the initial or complicating severe infection of the throat did not show much improvement prior to the onset of the empyema.

The deep red injection of the mucous membrane in the fatal cases continued with the empyema to the necropsy table where the tissues

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were frequently found to be stained from laked blood; the skin and conjunctiva during life in the severe cases frequently showed marked jaundice of hematogenous origin. In these cases S. hemolyticus was usually demonstrable.

It is noted also that the cases which had a slight but constant fever following the active stage of measles were the ones most liable to have the serious complications of empyema. One reason for this has been shown at necropsy where an interlobar lesion in such a stage of organization has been found as to definitely place its time of onset prior to the signs of empyema.

The most severe chest condition during the first 6 months of 1918 was empyema. Its relation to other diseases and its mortality from various points of view is shown in the tables. In this study a condition is designated empyema which shows an acute nontuberculous collection of purulent exudate in the pleural cavity.

TABLE 1

TOTAL NUMBER OF ADMISSIONS OF MEASLES AND RESPIRATORY CASES (BY MONTHS) SEPT. 25, 1917, TO JUNE 1, 1918

	Total Number of Cases										
	Tonsillitis (A)	Bronchitis (B)	Pharyngitis (C)	Laryngitis (D)	Stomatitis (E)	Rhinitis (F)	Total of A, B, C, D, E and F	Measles and Rubella	Pneumonia and Empyema Col. 17	Total Measles and Respiratory Cases	All Cases in Hospital
Sept.	7	19	......	......	......	6	32	6	2	40	172
Oct.	15	32	9	2	......	3	61	24	5	90	459
Nov.	55	32	13	4	......	3	107	165	5	277	599
Dec.	72	56	18	9	1	7	163	217	14	394	813
Jan.	288	304	117	26	......	4	739	244	63	1,046	1,809
Feb.	296	135	50	9	1	13	504	66	29	599	1,549
March	171	264	110	7	......	8	560	20	54	634	1,288
April	194	317	175	2	......	13	701	58	109	868	1,556
May	92	227	48	1	1	10	379	30	86	495	1,446
Total	1,190	1,386	540	60	3	67	3,246	830	367	4,443	9,691

The cases of empyema which gave the highest mortality were those which clinically presented the picture of severe septicemia. In the great majority of cases the exudate was thin, slightly turbid fluid, the smear showing pus cells and streptococci. This exudate often accumulated with great rapidity both in the cases secondary to pneumonia and those of primary origin, especially following measles. One severe case of primary empyema following a severe pharyngitis went, in 16 hours, from the stage of fibrinous exudate (a friction rub over the entire chest) to about 1,500 c c lemon yellow turbid fluid containing pus cells and great numbers of streptococci.

The second group of cases, not quite so fulminant in character, showed at the onset of the empyema, the same turbid fluid. The first group (fulminant) had a very high mortality with any operative procedure. The second group (less fulminant) often went to the thick pus stage several days later, at which time a costectomy was made.

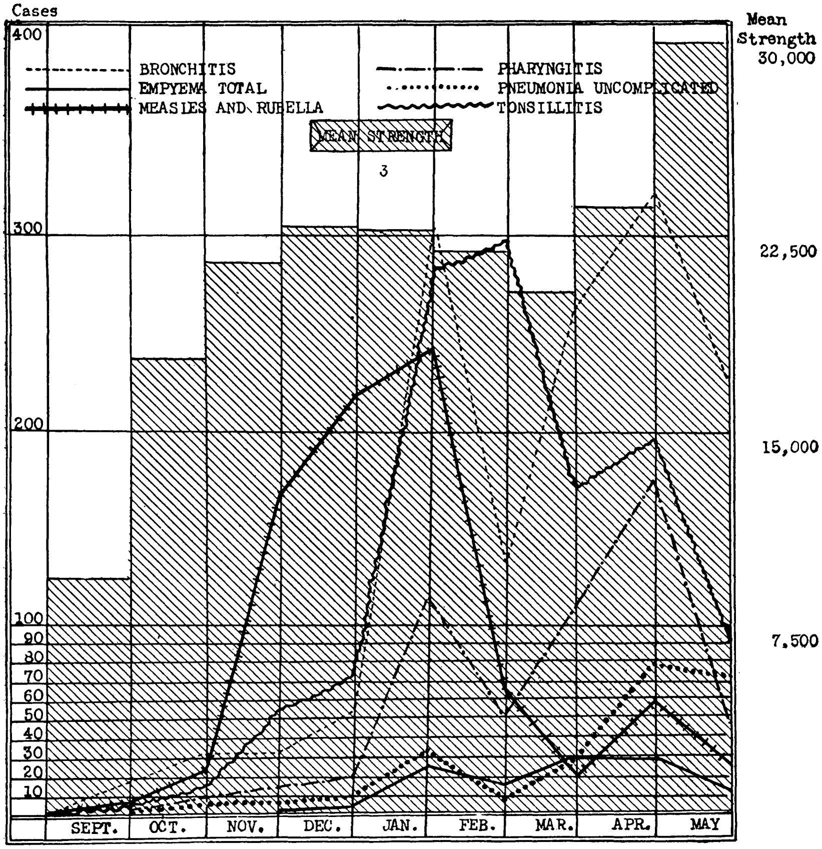
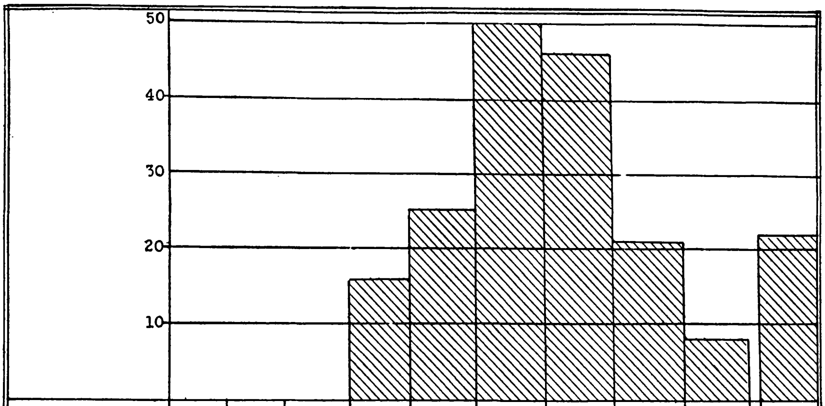


Chart 1.—Admissions of measles and respiratory cases by months.

In a third group of cases the symptoms were not such as to indicate the presence of a serious condition. The signs were of fluid in small or moderate amount. When aspirated after some days these cases showed (1) a turbid fluid containing pus cells and streptococci, or (2) a thick yellowish gray pus with many organisms, usually streptococci. Class 1 of this third group in 2 cases took care of the fluid without any operative interference, the second class did fairly well with costectomy.

A fourth group of three atypical cases which occurred all in one week during the middle of March, were of sudden onset, chill, high fever, small thready rapid pulse, and septic appearance. The chest showed signs of a small amount of fluid. Aspiration showed in all a few c c of very thick yellowish gray pus, one containing a doubtful streptococcus and the other two sterile. These cases had normal temperature in 2 or 3 days and made quick recovery without any operative interference other than the original exploratory tapping.

There seem to be 4 definite stages in the genesis of empyema: fibrinous, serofibrinous, serofibrinopurulent, and purulent.



	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	TOTAL
No. of cases of pneumonia	2	5	5	12	40	18	46	99	81	308
No. of cases of Empyema complicating pneumonia	0	0	0	2	10	9	21	20	6	68

Chart 2.—Relative incidence of empyema complicating pneumonia.

The usual early finding for a variable period of about a week is the serofibrinopurulent exudate. At necropsy there frequently was found a serofibrinopurulent exudate in one pleural cavity, and a fibrinous or serofibrinous in the other. It is important to recognize further, that while the course is usually progressive through the various stages toward the end or purulent stage, the fibrinous or serofibrinous pleuritis may proceed no further than those stages, the case not being a true empyema. These first two stages are frequently found in cases of pneumonia and great care should be exercized that the cases

TABLE 2

Total Number of Admissions of Measles and Respiratory Cases (by Months) Sept. 25, 1917, to June 1, 1918

	1 Measles			2 Rubella			3 Total Measles and Rubella			4 Measles Complicated by Pneumonia			5 Rubella Complicated by Pneumonia			6 Total Measles and Rubella Complicated by Pneumonia		
	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality
September.......	1	....	....	5	....	....	6											
October..........	22	....	....	2	....	....	24											
November........	117	....	....	48	....	....	165											
December........	176	1	0.6	41	1	2.4	217	2	0.9									
January.........	207	9	0.4	37	....	....	244	9	3.8	3	....	....	1	....	....	4		
February........	58	2	3.5	8	....	....	66	2	3.0	2	1	50.0	....	....	....	2	1	50.0
March...........	13	1	7.7	7	....	....	20	1	5.0	2	1	50.0	....	....	....	2	1	50.0
April............	29	2	6.9	29	....	....	58	2	3.4	3	1	33.3	....	....	....	3	1	33.3
May.............	23	3	13.0	7	....	....	30	3	10.0									
Total..........	646	18	2.8	184	1	0.5	830	19	2.3	10	3	30.0	1	....	....	11	3	27.2

[No cases in Sept., Oct., Nov.]	7 Primary Empyema			8 Measles Complicated by Empyema			9 Rubella Complicated by Empyema			10 Total Measles and Rubella Complicated by Empyema			11 Measles Complicated by Pneumonia and Empyema			12 Total Empyema Following Measles and Rubella		
	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality
December........	....	....	....	1	1	100.0	1	1	100.0	2	2	100.0	....	....	....	2	2	100.0
January.........	5	1	20.0	12	7	58.3	....	....	....	12	7	58.3	2	2	100.0	14	9	64.5
February........	4	2	50.0	5	1	20.0	....	....	....	5	1	20.0	....	....	....	5	1	20.0
March...........	6	1	16.7															
April............	5	1	20.0	2	1	50.0	....	....	....	2	1	50.0	....	....	....	2	1	50.0
May.............	2	....	....	1	1	100.0	....	....	....	1	1	100.0	2	2	100.0	3	3	100.0
Total..........	22	5	22.7	21	11	52.4	1	1	100.0	22	12	54.5	4	4	100.0	26	16	61.5

	13 Lobar and Bronchopneumonia Complicated by Empyema			14 Total Empyema			15 Lobar and Bronchopneumonia Uncomplicated			16 All Pneumonias			17 Total Pneumonias and Empyemas of All Kinds		
	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality	No. of Cases	No. of Deaths	% Mortality
September.....	....	....	....	....	....	....	2	1	50.0	2	1	50.0	2	1	50.0
October........	....	....	....	....	....	....	5	....	....	5	....	....	5		
November......	....	....	....	....	....	....	5	....	....	5	....	....	5		
December......	2	....	....	4	2	50.0	10	....	....	12	....	....	14	2	14.2
January.......	10	3	30.0	29	13	44.9	30	5	16.7	46	10	21.8	63	18	28.6
February......	9	2	22.2	18	5	27.8	9	1	11.1	20	4	20.0	29	7	25.5
March..........	21	11	52.4	27	12	44.4	25	5	20.0	48	17	35.4	54	18	33.3
April...........	20	9	45.0	27	11	40.7	79	10	12.7	102	20	19.6	109	22	20.2
May............	6	1	16.7	11	4	36.4	75	9	12.0	83	12	14.4	86	13	15.1
Total........	68	26	38.2	116	47	40.5	240	31	12.9	323	64	19.8	367	81	22.1

* All deaths are recorded by months as of the time entering hospital and not by actual date of death. This table includes all deaths up to June 26, 1918.

Col. 3 is a total of Cols. 1 and 2 and gives the total incidence and mortality, from all complications of all measles and rubella based on Cols. 6, 10 and 11.

Col. 6 is a total of Cols. 4 and 5 and includes those cases of measles and rubella which had pneumonia as to the only complicating chest condition.

Col. 7 includes all cases of empyema which did not follow pneumonia or measles.

Cols. 8 and 9 include (each as designated) those cases of empyema which were primary so far as chest findings were concerned but which followed measles or rubella.

Col. 10 is a total of Cols. 8 and 9.

Col. 11 includes those cases of empyema which followed measles but in which the primary chest condition was definitely a pneumonia with the empyema secondary to the pneumonia.

Col. 12 is a total of Cols. 10 and 11, i. e., all cases which followed measles or rubella.

Col. 13 includes all cases of lobar and bronchopneumonia (uncomplicated by measles or rubella) followed by empyema.

Col. 14 is a total of Cols. 7, 12 and 13 and includes all cases of empyema without regard to any preceding condition.

Col. 15 includes all cases of lobar and bronchopneumonia uncomplicated by empyema or measles.

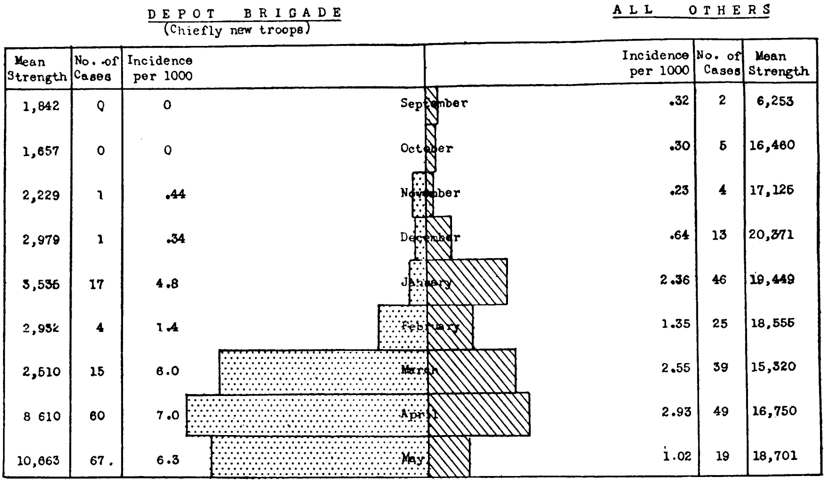
Col. 16 is a total of Cols. 6, 11, 13 and 15 and includes all cases of pneumonia uncomplicated (15), complicated by empyema (13), complicating measles and rubella (6) and complicating measles complicated by empyema (11).

Col. 17 is a total of Cols. 6, 7, 12 13 and 15 and includes all cases of pneumonia and empyema without regard to complications.

of serofibrinous exudate are not thought cases of empyema and operated on. Neither should the possibility of a fluid being purulent be lost sight of.

During the month of January the high mortality of empyema cases was due to those cases which followed measles. These showed great virulence of the infecting organism and a very fulminant course. The high mortality of January was further due to the fact that the course of the new type of empyema was not clearly understood at the outbreak of this condition.

During the month of February, March and April there were only 6 cases of empyema following measles, none during March and only 2 in April, but there were relatively few cases of measles. During March the mortality from pneumonia complicated by empyema was high (52.4%); nine of the 12 fatal cases for March, however, were admitted to the hospital on or after March 27. Taking a period from March 27 to May 1, 1918, the cases of pneumonia complicated by empyema were 34 with mortality of 50%, the mortality of pneumonia uncomplicated by measles or empyema for the same period was 14.3%. These are more nearly the real figures for this group of cases during this period than those from April 1 to May 1. The mortality of uncomplicated cases of pneumonia did not seem to perceptibly increase,


DEPOT BRIGADE
(Chiefly new troops)

ALL OTHERS

Mean Strength	No. of Cases	Incidence per 1000		Incidence per 1000	No. of Cases	Mean Strength
1,842	0	0	September	.32	2	6,253
1,657	0	0	October	.30	5	16,460
2,229	1	.44	November	.23	4	17,126
2,979	1	.34	December	.64	13	20,371
3,536	17	4.8	January	2.36	46	19,449
2,932	4	1.4	February	1.35	25	18,555
2,510	15	6.0	March	2.55	39	15,320
8 610	60	7.0	April	2.93	49	16,750
10,663	67.	6.3	May	1.02	19	18,701

Chart 3.—Incidence of pneumonia and empyema in the depot brigade (chiefly raw recruits) and the other organizations of the cantonment composed of more seasoned soldiers.

while the mortality in pneumonia complicated by empyema was considerably higher, nearly double that of the preceding months.

The mortality tables of the various conditions follow:

	Pneumonia	Primary Empyema	Measles Empyema	Broncho-pneumonia and Empyema	Pneumonia and Empyema	Total Empyema
January	16.7	20	64.3	22.2	30.0	44.9
February	11.1	50	20.0	14.3	22.0	27.8
March 1 to 27	14.2	00	00.0	†42.8	42.8	30.0
*March 27 to May 1	14.3	50	50.0	50.0	50.0	51.3
May	12.0	00	100.0	33.3	16.7	36.4
Total Sept. 25 to June 1, 1918	12.9	22.7	61.5	35.6	38.2	40.5

* Several factors at this time, from March 27 to May 1, had important bearing on the character and severity of the condition and on the kind of operative procedure instituted. The greater number of these cases were newly drafted men, some of whom still showed the effects of previous alcoholism, one case having delirium tremens with pneumonia and empyema. The infection was severe and their resistance was definitely low, several patients dying within 3 days after entrance to the hospital. The cases were very septic at the onset, as in January when the same conditions held though to a less degree.

† Of the 3 fatal cases, 2 were treated by costectomy, the third by aspiration.

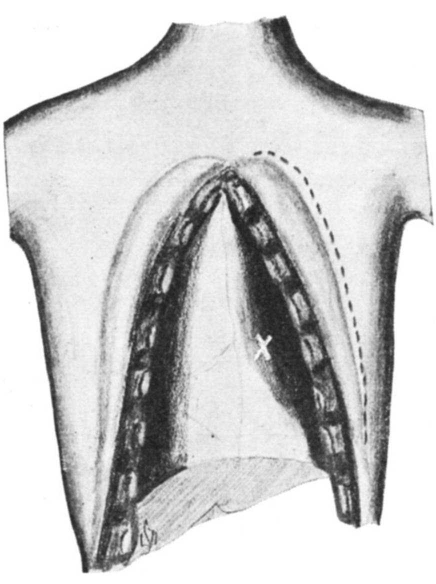
The cases of primary empyema and of empyema following measles are so few that by months the mortality figures are of little value. The totals for the period up to June 1, are based on sufficient number of cases to give a more reliable rate for these conditions.

TABLE 3

ADMISSIONS AND DEATHS ACCORDING TO LENGTH OF SERVICE

Pneumonia (Totals of Columns 6 and 15, Table 2)	1/12 Service			2/12 Service			1/12 and 2/12 Service Combined			All Others		
	Cases	Deaths	% Mortality	Cases	Deaths	% Mortality	Cases	Deaths	% Mortality	Cases	Deaths	% Mortality
September	1	.....	....	....	.....	....	1	.....	....	1	1	100.0
October	3	.....	....	1	.....	....	4	.....	....	1		
November	3	.....	....	1	.....	....	4	.....	....	1		
December	6	.....	....	....	.....	....	6	.....	....	4		
January	15	2	13.3	11	1	9.1	26	3	11.5	8	2	25.0
February	....	.....	....	1	.....	....	1	.....	....	10	2	20.0
March	6	3	50.0	1	.....	....	7	3	42.9	20	3	15.0
April	44	7	15.9	2	1	50.0	46	7	15.2	36	4	11.1
May	62	7	11.3	....	.....	....	62	7	11.3	13	2	15 4
Totals	140	18	12.9	17	2	12.5	157	20	12.7	94	14	14.9
Empyema (Col. 14. Table 2)												
September	....	.....	....	....	.....	....	....	.....	....	....	.....	....
October	....	.....	....	....	.....	....	....	.....	....	....	.....	....
November	....	.....	....	....	.....	....	....	.....	....	....	.....	....
December	3	2	66.7	....	.....	....	3	2	66.7	1	.....	....
January	15	4	26.7	5	4	80.0	20	8	40.0	9	5	55.5
February	....	.....	....	4	1	25.0	4	1	25.0	14	4	28.6
March	4	2	50.0	3	.....	....	7	2	28.6	20	10	50.0
April	12	6	50.0	3	1	33.3	15	7	46.7	12	4	33.3
May	7	1	14.3	3	2	66.7	10	3	30.0	1	1	100.0
Totals	41	15	36.6	18	8	44.4	59	23	39.0	57	24	42.1

Primary empyema (primary so far as the lung condition is concerned) was found most frequently following measles. In these cases the usual early and persistent signs were those of fluid rather than of consolidation. At necropsy an accompanying bronchopneumonia, however, was present in a great majority of cases, it being impossible to state with any degree of assurance whether the empyema or the pneumonia was the older process. The state of consolidation and the degree of organizattion of the exudate in several cases was so evident, however, as to definitely place the empyema as the primary condition. Further evidence of this priority of empyema was obtained from the distribution of the pneumonia, as the consolidation appearing at the periphery as a shell, apparently secondary to an overlying empyema by an extending infiltration; or even completely encircling an interlobar empyema like a thick orange rind.



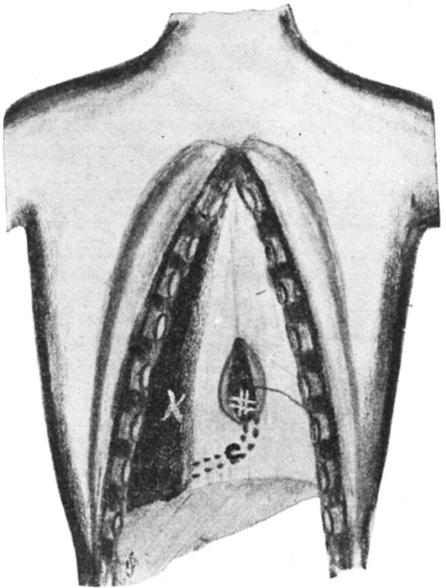


Fig. 1.—Double empyema. Costectomy on the right side and repeated aspiration on the left. X, an anterior pocket which extended from the apex to the diaphragm and contained 500 c.c. of thin turbid fluid; this did not connect with a similar posterior pocket containing 1,400 c c of a similar fluid. A flat atelectatic lung was attached at the dotted line by fresh adhesions, definitely forming a partition separating the two pockets. Necropsy was done 18 days following the costectomy.

Fig. 2.—Empyema on the right side with pocket formation. Thoracotomy on the right. Both pockets thoroughly drained and cleaned; Dakin's solution had been used. X marks a lateral cavity connecting with #, the latter being an anterior cavity situated between mediastinal parietal pleura and visceral pleura, anterior to the hilus, by C, canal 2 inches long, the size of the little finger. After operation, a pneumonia developed on the left side. Necropsy was performed 23 days after the operation.

The early recognition of empyema depends on constant attention, alertness and accuracy of observation. Repeated critical examinations with careful notations are of great value, especially when graphically indicated on a chest outline allowing a quick and easy comparison of findings. Dulness or flatness with the sense of resistance on percussion, together with the diminution or absence of tactile fremitus, are the most reliable signs. The signs may be looked for in any portion of the chest, as there is no place that the fluid may not accumulate, anterior or posterior, superior or inferior, medial, lateral or interlobar.

The site for thoracentesis is the point where the signs are most definite. Fluid has been aspirated from different pockets in various locations, just inside the right nipple, high and low in the axilla, near the sternum, beneath the clavicle, midscapular region and at the extreme base. One pocket was located at a depth of 2 inches in the interlobar fissure; another cylindrical pocket extending from the surface to a depth of 15 cm., more of a sinus than a pocket, the size of a finger, with the end of the cylinder at about the angle of the scapula. The pocket formation may be the result of old or new adhesions (Figs. 1 and 2 show the pocket formations).

TABLE 4

TABULATION OF 137 BLOOD CULTURES IN RELATION TO DISEASE AND MORTALITY

	Living		Dead	
	Positive	Negative	Positive	Negative
Pneumonia	2	64	3	11
Measles complicated by pneumonia	0	1	0	1
Measles complicated by pneumonia and empyema	0	0	1	1
Measles complicated by empyema	0	0	1	1
Primary empyema	0	5	0	1
Pneumonia complicated by empyema	3	20	11	11
Totals	5	90	16	26

The roentgen ray has been of very great assistance, not only in determining whether consolidation or pleural fluid was present, but in locating the lesions with precision in a number of cases.

An irregular temperature after pneumonia often led to careful scrutiny of the patient, a collection of pus not infrequently being found interlobar or in some other less usual location. At other times, the temperature being normal for many days, pockets of pus were located by routine careful examination in patients thought to be making an uncomplicated convalescence.

The mortality of cases of empyema as reviewed by months in relation to (1) incidence and mortality of antecedent and accompanying disease (Table 2), and (2) the kind of operative procedure instituted, is instructive.

A negative blood culture does not mean that septicemia is not present. While indeed most of the fatal cases probably had at least a terminal septicemia, it is not believed that these cases at the outset were necessarily predetermined deaths, nor does it seem that it can be fairly stated that because the patients died, they were hopeless from the beginning by reason of there being septicemia present.

From the opening of the hospital, Sept. 27, 1917, to June 26, 1918, there were 116 cases of empyema with 49 deaths. (Two patients died since the tables were completed, one of streptococcus septicemia-positive blood culture, and the other of miliary tuberculosis.)

Of the 67 living, 58 have been discharged from the hospital cured; of the remaining nine, several have required secondary operations but all are doing well and it is expected that they will soon be discharged.

Statistics taken from time to time showing the prevalence of streptococci in the throats of patients entering the hospital and of apparently healthy men throughout the camp are presented. These include data collected from cultures taken for the detection of diphtheria carriers, the routine cultures from patients entering the hospital with suspicious throats, cultures made in a number of patients to determine whether or not they had acquired streptococci during their stay in the hospital, cultures made in 2 empyema and 2 pneumonia wards and a series of cultures made on a company of new draft men.

Table 5 shows the occurrence of streptococci in the throats of patients, and of apparently healthy men on culture to determine the number of diphtheria carriers. The cultures in the latter case were made on Loeffler's serum. After incubation, smears were stained with methylene blue. Incidental to the search for diphtheria bacilli the presence of organisms morphologically streptococci were noted.

A survey of these statistics would indicate that streptococci have been present in the throats of apparently healthy soldiers and patients in the hospital of this camp in a percentage comparable to a percentage which has been found by other workers in healthy individuals in civil life.

Coincident with the arrival of negro troops from Alabama, Type I pneumococcus pneumonia became almost epidemic. During May, 25 cases were diagnosed. Eighteen of these occurred in negro troops.

A large number of these came from 2 barracks (74 and 76). The company occupying Barracks 76 was examined to determine how many men carried Type I pneumococcus. In 98 men, one Type I and eleven Type II organisms were found. The Avery method was used to determine the agglutinable organisms. Blood-agar plates were inoculated from the 24-hour culture. Approximately 15% showed hemolytic colonies of the streptococcus type.

There are also available the results of study of 29 cultures of organisms morphologically streptococci on blood-agar.

TABLE 5

OCCURRENCE OF STREPTOCOCCI IN THROAT CULTURES FOR VARIOUS PURPOSES

	Feb.	Mar.	Apr.
Total number of cultures on diphtheria carriers	853	340	86
Total number containing streptococci	268	205	17
Per cent. containing streptococci	31.4%	60.2%	19.5%

The same technic was used in making cultures on patients entering the hospital. The cultures were made in the receiving office on all patients having suspicious throats:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Total number of cultures	3	15	107	145	291	135	209
Number containing streptococci	1	13	71	81	203	110	154
Per cent. containing streptococci	33.3%	86.7%	60%	55.9%	69.5%	74.8%	73.7%

Cultures were made in the same way on the patients in 4 measles wards for another purpose, the incidence of streptococci being noted:

	Feb. 5	Feb. 7	Feb. 11	Feb. 13
Total number of cultures	85	34	57	50
Number containing streptococci	54	23	28	30
Per cent. containing streptococci	63.5%	67.6%	49%	60%

A series of cultures were made on a group of patients in the hospital to determine whether or not they acquire hemolytic streptococci in the throat during their stay. For this purpose the cultures were made on plain blood agar plates and the colonies producing wide zones of complete hemolysis and shown to be gram-positive cocci in chains, were diagnosed as hemolytic streptococci:

	Apr. 30	May 2	May 6
Total number of cultures	51	45	35
Number containing streptococci	11	9	2
Per cent. containing streptococci	21%	20%	5.7%

Throat cultures using the latter technic were made on patients in 2 pneumonia and 2 empyema wards:

	Empyema Wards		Pneumonia Wards	
	Ward 14	Ward 16	Ward 21	Ward 22
	Apr. 30	Apr. 30	May 6	May 6
Total number of cultures	21	20	24	34
Number containing streptococci	5	8	8	3
Per cent. containing streptococci	20%	40%	33%	8.5%

A company of new draft men was cultured shortly after arrival and every 7 days thereafter for 3 successive cultures. These cultures were made on Loeffler's serum, smears stained by methylene blue:

	Apr. 29	May 6	May 13	May 20
Total number of cultures	100	91	85	65
Number containing streptococci	39	33	40	27
Per cent. containing streptococci	39%	33%	47%	41%

The results of sputum typing is shown in Table 7. The Avery method with the exception of a few cases has been relied on for the reason that mice were not available and because it is a more simple and economical procedure than the mouse method.

Blood cultures for the most part have been sterile. The technic has been to inoculate from 5-10 c c of blood into 200-300 c c of glucose

TABLE 6

Streptococcus Cultures

Date	Source	Length (Aver.)	Blood-Agar Plate
Feb. 4	Chest fluid	6-12 cocci	Hemolysis complete
Feb. 4	Throat	10-20 cocci	Hemolysis complete
Feb. 5	Sputum	20-30 cocci	Green producing
Feb. 6	Throat	30-60 cocci	No hemolysis
Feb. 6	Throat	20-30 cocci	No hemolysis
Feb. 6	Throat	10-20 cocci	No hemolysis
Feb. 6	Blood culture	8-16 cocci	No hemolysis
Feb. 6	Chest fluid	8-16 cocci	No hemolysis
Feb. 7	Sputum	8-16 cocci	Hemolysis complete
Feb. 7	Sputum	8-16 cocci	Hemolysis complete
Feb. 10	Appendix	8-16 cocci	Hemolysis complete
Feb. 15	Chest fluid	10-25 cocci	No hemolysis
Feb. 15	Throat	8-16 cocci	No hemolysis
Feb. 15	Chest fluid	8-16 cocci	Hemolysis complete
Feb. 15	Sputum	8-16 cocci	No hemolysis
Feb. 15	Sputum	10-30 cocci	Hemolysis complete
Feb. 18	Blood, postmortem	10-30 cocci	Hemolysis complete
Feb. 18	Blood, postmortem	10-30 cocci	Hemolysis complete
Feb. 26	Blood, during life	10-30 cocci	Hemolysis complete
Feb. 26	Chest fluid	10-30 cocci	Hemolysis complete
Feb. 28	Sputum	10-18 cocci	Hemolysis complete
Feb. 28	Sputum	10-18 cocci	No hemolysis
Feb. 28	Axillary abscess	10-18 cocci	Hemolysis complete
Feb. 28	Chest fluid	Moderate	Hemolysis complete
Mar. 18	Chest fluid	Long	No hemolysis
Mar. 20	Sputum	Short	No hemolysis
Mar. 20	Blood culture	Long	Hemolysis complete
Apr. 1	Chest fluid	Long	Hemolysis complete
Apr. 1	Chest fluid	Long	Hemolysis complete

Total number of cultures 29
Number showing complete hemolysis .... 17 or 58%

TABLE 7

Bacteriologic Study of Sputum

	Type I	Type II	Type III	Type IV	Streptococcus		B. Influenzae	B. Capsulatus	Undetermined	Total
					Alone	With Type IV				
January	0	6	0	21	3	6	0	0	0	36
February	0	2	0	3	15	1	0	0	0	21
March	0	1	0	2	12	0	0	0	1	16
April	1	5	0	0	56	0	0	0	37	99
					Hemolytic	Non-hemolytic				
May	26	11	0	23	11	7	4	8	0	90
Total	27	25	0	49	111		4	8	38	262

broth which is then shaken. The cultures were then incubated and examined at the end of 24, 48 and occasionally 72 hours. Table 8 is a summary of this work:

TABLE 8

BLOOD CULTURES

Number of cases with no culture	148
Number of cases with culture	146
Total number of cases	294
Number of negative cultures	133
Number of positive cultures	21
Per cent. positive	13%

Mortality of cases showing positive blood cultures.

		Cases	Mortality
Streptococcus		17	89%
Pneumococcus	Type I	2	00
	Type II	1	00
	Type III	0	00
	Type IV	1	100%
Total		21	81%

The predominating organism has been a streptococcus. The pneumococcus has been demonstrated but 4 times. The streptococcus present has been a long chain organism, considered in the early cases to be identical with the hemolytic. In the majority of instances when grown on blood agar these organisms have produced wide zones of complete hemolysis about colonies. Since May 1, every streptococcus found in a pleural exudate has been shown to produce complete hemolysis on blood agar. To further identify these organisms more recent cultures have been grown on blood agar and in sugars. Twenty-two cultures from as many cases have been examined in this way. Three of these have been pneumococcus infections. The other 19 all produced wide zones of complete hemolysis, and failed to ferment mannite and inulin. In these respects they may be considered identical organisms.

Leukocyte counts have been made in the majority of cases. The average for the total 142 counts was 17,000. The lowest count was 3,000, the highest 58,000. In a large number of cases the leukocytosis has been greater than 30,000 especially at the time when the empyema was discovered. No constant relationship existed between the degree of the leukocytosis and the mortality. Both the patients having the counts of 3,000 and 58,000 died.

Seventy-one blood cultures were made on 55 cases of empyema, 18 were found to contain streptococci, 3 pneumococci, positive 28.5%. Six of the cultures yielding streptococci were obtained postmortem.

Of the remaining, 6 patients having a streptococcemia antemortem lived, 6 died; one having pneumococcemia; one died. One pneumococcus was demonstrated postmortem.

The sputum was typed in 47 cases of pneumonia complicated by empyema. In 33, streptococci were demonstrated; in 13, a pneumococcus; 4 had Type II organisms, the others Type IV. In one case a diagnosis was not arrived at.

The organisms found in the chest fluid have been in 91 cases the streptococcus; in 2, pneumococcus Type II; in 2, pneumococcus Type IV. In 9 cases no organisms were demonstrated in the pleural exudates.

TABLE 9

CULTURES GROWN ON BLOOD AGAR AND SUGARS

No.	Source	Blood Agar	Dextrose	Lactose	Mannite	Saccharose	Inulin
1	Chest fluid	Hemolysis	+	+	—	+	—
2	Chest fluid	Hemolysis	+	+	+	+	—
3	Chest fluid	Hemolysis	+	+	—	+	—
4	Chest fluid	Hemolysis	+	+	—	+	—
5	Chest fluid	Hemolysis	+	+	+	+	—
6	Chest fluid	Hemolysis	+	+	+	+	—
7	Chest fluid	Hemolysis	+	+	+	+	—
8	Chest fluid	Hemolysis	+	+	+	+	—
9	Chest fluid	Hemolysis	+	+	—	+	—
10	Chest fluid	Hemolysis	+	+	+	+	—
11	Chest fluid	Hemolysis	+	+	—	+	—
12	Chest fluid	Hemolysis	+	+	+	+	—
13	Chest fluid	Hemolysis	+	+	—	+	—
14	Chest fluid	Hemolysis	+	+	—	+	—
15	Chest fluid	Hemolysis	+	+	—	+	—
16	Chest fluid	Hemolysis	+	+	+	+	—
17	Chest fluid	Hemolysis	+	+	—	+	—
18	Chest fluid	Hemolysis	+	+	—	+	—
19	Chest fluid	0	+	+	+	+	+
20	Chest fluid	0	+	+	+	+	+
21	Chest fluid	0	+	+	+	+	+
22	Chest fluid	0	+	+	+	+	+

+ = acid production; — = no reaction.

Four of these cultures were considered pneumococcus because of the morphology, fermentation of inulin and production of methemoglobin.

Number 19 agglutinated with Type 2 antipneumococcus serum.

Number 21 agglutinated with Type 1 antipneumococcus serum.

In general, the findings in sputum, blood culture and chest fluid have corresponded. In only 3 cases have the organisms in the blood differed from those found in the chest fluid. Two of these had Type II pneumococci in their blood with streptococci in their chest fluid. In one a pneumococcus Type IV was found in the chest fluid with a streptococcus in the blood stream.

There have been 37 necropsies, in a series of 71, on cases of pneumonia and empyema, empyema occurring in 29.

The results show that the infection in these cases has not been limited to pleural cavities, but has in the majority of instances, been found in various locations. These facts together with the results of the blood cultures would seem to indicate that, at least in fatal cases, the infection was systemic. A streptococcus has been identified in the majority. Measles was a factor in 12 cases. In these 12 cases, empyema followed or was associated with bronchopneumonia in all except two.

The most constant picture at necropsy has been a serofibrinopurulent pleuritis associated with bronchitis and bronchopneumonia. There have been 15 cases with right sided lesions, 10 with left, 4 bilateral.

In the early cases the pleural lesion consists of a large amount of exudate which compresses the lung against the hilus to a varying degree. The pleural surfaces have been covered uniformly with a layer of fibrin the thickness of which depends on the age of the process. The interlobar fissures have been found sealed tightly. In a few cases a pocket of pus has formed in the fissure, the exudate between the lobes becoming purulent. In other cases the base of the lung has been bound firmly to the diaphragm, a dome-shaped pocket of pus forming in this location. Pocket formation has been shown far more frequently clinically than at necropsy. In old cases the pleural cavities become obliterated and the undrained pus enclosed by thick walls of organizing exudate. The cause of death in case of long duration has usually been due to an extending process. One patient died with a marked acute glomerulo-nephritis. The rapidly developing fulminant cases rarely have any changes other than those found in the chest to which the cause of death may be attributed.

The lung lesions in these cases have been almost identical with the descriptions of MacCallum. With large amounts of fluid or pneumothorax in the operated cases and corresponding atelectasis, usually the lung of the opposite side has presented the most typical picture of the pneumonic process. When the fluid has not been too great, a lobe on the same side may present a typical picture. Bronchopneumonia has been associated with empyema in 22 cases and in 4 others no pneumonic process was described. The lobar pneumonia encountered has not been unusual.

The bronchopneumonia encountered presents several striking features. In general, it has been extensive and patchy in distribution, involving a whole lobe or lung so that it is easy to see how such a case clinically would be considered a lobar process. The lung has had a fairly firm consistency, however, the type of consolidation has not been that of lobar pneumonia. On section innumerable, widely scattered, deep red, dry, elevated areas appear throughout the lobe or lung between which apparently normal alveolar tissue could be demonstrated. In such a section small abscesses would be encountered, but no direct connection between these abscesses and the bronchi could be shown. In later stages the lung tissue was distinctly yellowish or grayish representing what appeared to be a resolving process. The congestion and edema in some cases was so marked as to give the lung the appearance of raw meat. In the few cases examined microscopically the pneumonic process is described as peribronchial in type.

Peritonitis occurred in 6 cases. In 2 the appendix, according to history and clinical course, was the primary lesion, the peritonitis developing subsequently. In one of these the pleural lesion was recognized antemortem; in the other postmortem. In 2 cases no focus was found within the abdomen. In these the widespread infection was attributed to the virulence of the organism. In 2 cases a localized diaphragmatic peritonitis was demonstrated, particularly over the liver, the pleural lesions in both instances being on the right side. Though no conclusive evidence was found it seems probable that in these cases the peritoneal infection took place by direct extension through the diaphragm.

Pericarditis occurred 7 times. In one case it was extremely slight, manifested by a slightly turbid fluid and a few threads of fibrin on the auricles. The others have been described as hemorrhagic, serofibrinous or purulent. They are undoubtedly only a manifestation of a general septicemia and as such should be regarded as terminal lesions.

Mediastinitis, manifested by purulent exudate in the mediastinal tissues, has been encountered in 3 cases.

SUMMARY

Respiratory infections in 1917 and 1918 occurred among troops in waves, the greatest severity of the diseases being at the height of each wave. Not only were pneumonia and empyema more frequent and severe, but also tonsillitis, pharyngitis and bronchitis.

The most serious infections were characterized by septicemia with empyema, peritonitis, phlegmon and rarely arthritis; and by pulmonary infection (pneumonia, lobular or lobar in distribution) with consecutive empyema.

While patients who were passing through measles infection were more severely affected by the streptococcal invasion, the 2 infections should be regarded as separate even though they were coincident. The empyema and pneumonia were not the result of the measles infection but of the prevailing severe respiratory infections of that period. The marked freedom from complications of the group of measles treated during the fall and winter of 1917 when general streptococcal infections were absent in camp, and the severe wave of pneumonia and empyema (streptococcal) of April, 1918, when measles was on the wane and which involved for the most part soldiers who had not had measles, are points in support of this view.

In a group of 115 consecutive cases of pneumonia and empyema a definite history of an acute antecedent bronchitis, pharyngitis or tonsillitis was obtained in over 80% of the cases.

In the majority of cases of empyema, a streptococcus has been the causative organism. When grown on blood agar it has been shown to be usually hemolytic. During the period of prevalence of empyema, streptococci were demonstrable in the majority of the throats of healthy soldiers (including fresh recruits) as well as of patients entering the hospital with respiratory infections.

The clinical manifestations of empyema include rapid and profound toxemia, the quick formation in many cases of large amounts of pleural exudate, and a marked tendency to pocket formation by old and new adhesions in atypical locations.

The mortality was highest (61.5%) in the cases of empyema following measles, and the lowest (22.7%) in the cases in which empyema was the primary condition. (Cases following measles are not designated primary.) In empyema complicating pneumonia the mortality was 38.2%; the mortality of all cases of empyema was 40.5%.

At necropsy the outstanding features have been the finding of widespread lesions with a tendency to involve serous membranes, the occurrence of a severe bronchitis in the majority of cases, and a type of bronchopneumonia so distributed as often to closely resemble a lobar process.

Early recognition of empyema is important, especially in the acute fulminant types of cases. The diagnosis depends on close attention to clinical progress, frequent observations accurately made and recorded, and proper interpretation of physical signs. Dulness, the sense of resistance on percussion, and the diminution or absence of tactile fremitus are the most reliable signs.

The relative incidence of empyema complicating pneumonia was high, one month 50% of pneumonia cases developing empyema.

Of 830 cases of measles (including rubella), 4.4% developed pneumonia or empyema; of this group, empyema was the primary condition clinically in 70% of the cases.

The control of such epidemics would appear to depend on the sanitation in barracks as regards ventilation; adequate space and proper separation, especially of those even slightly affected with respiratory disease; on line officers not allowing overheated men to stand inactive in cold winds; on not indiscriminately giving triple typhoid inoculations at the very entrance of the soldier to camp without regard to any respiratory infection he might have at the time; on careful attention to overexertion and exposure of soldiers having mild respiratory disease, and on close attention to the details of equipment to ensure adequate clothing for the unacclimated raw recruit on his arrival.